

### Objectives

The objectives of these activities are the following:

1. to learn about the biological and physical conditions that lead to a harmful algal bloom
2. to use real data to predict the fate of a harmful algal bloom
3. to research the causes of a recent harmful algal bloom

### Materials

- Access to the Internet
- Access to newspapers/magazines

### Background

Algal blooms only occur when a number of biological and physical factors come together in an ideal way for that particular species. Scientists use an equation to express this relationship:

# of phytoplankton cells = growth of cells – loss of cells ± dispersion

**Growth**—The growth or photosynthesis of phytoplankton cells will depend on several factors. Most importantly, the phytoplankton cells must have access to sunlight and nutrients, as they use these as fuel for growth. In addition, the cells must be within an appropriate temperature range so it is not too hot or too cold.

**Loss**—Cell loss occurs mostly through grazing by predators or through viral infection, which can kill the cells. If the cells produce a toxin then the grazing rate on that type of cell may

be dramatically reduced allowing it to grow much faster than any other species.

**Dispersion**—Phytoplankton do not live in a static environment; the ocean is always moving. These movements in the ocean can carry phytoplankton to new locations, concentrate the number of cells, or mix up a concentrated area causing a bloom to dissipate.

### Activity #1



#### *Karenia brevis* Bloom

In the fall of 1987, a massive harmful algal bloom (HAB) occurred off the coast of North Carolina. It was caused by a phytoplankton species called *Karenia brevis*. Fishermen first noticed the bloom when the color of the water began to change. They also began to note respiratory problems and eye irritation. Over the course of the bloom, 48 cases of neurotoxic shellfish poisoning were reported. The bloom also caused approximately 1,500 km<sup>2</sup> of shellfish beds to be closed and resulted in \$24 million in economic losses. The bloom was particularly interesting from a scientific perspective in that a bloom of *K. brevis* had never been previously reported north of Florida! So, how did the bloom occur?

In performing their research, scientists discovered that there had been a bloom of *K. brevis* earlier in the season off the Florida coast. Would it be possible for the phytoplankton to travel from Florida to North Carolina, a distance of almost

700 miles (or 1180 km)? There is a current that runs up the East Coast of the United States from Florida called the Gulf Stream (Figure 1). Could the Gulf Stream carry phytoplankton for such a distance?

There are several pieces of evidence to support this interpretation. *K. brevis* are positively phototactic. This means that during the day they swim towards the sunlight, which tends to concentrate the cells at the ocean's surface. This behavior allows *K. brevis* to be moved more easily by winds and currents. Given the speed of the Gulf Stream, the bloom traveled from Florida to North Carolina in a reasonable amount of time. In addition, satellite images showed that in the beginning of autumn, waters from the Gulf Stream (a meander) came onto the continental shelf off of North Carolina. This provided a mechanism for the cells to be moved from Florida to the near-shore waters off the coast of North Carolina.

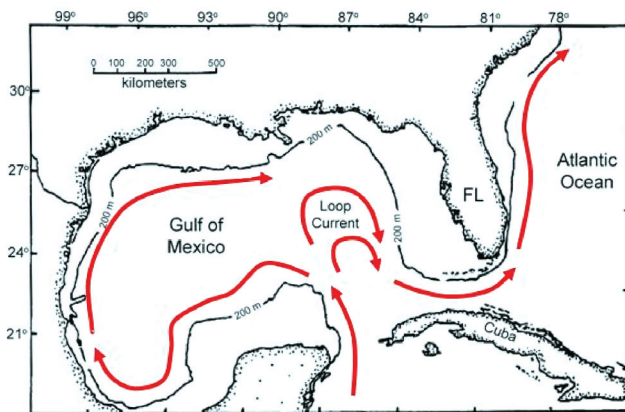


Figure 1. The average surface circulation for the Gulf of Mexico and East Coast is shown above. The Loop current moves into the Gulf of Mexico and moves clockwise around the Gulf. It leaves the Gulf south of Florida and becomes the Gulf Stream, which moves up the East Coast.

In this case, all of the conditions were optimized to allow *K. brevis* to increase to very high numbers near North Carolina. The phytoplankton were able to access light because they swam towards the surface. The Gulf Stream water was warm, giving the phytoplankton the correct temperature range. Losses were apparently low. Although not directly studied, it

can be assumed that grazing and viral infection were not major players. Perhaps the toxins produced by *K. brevis* decreased grazing rates. Finally, the physical conditions were such to allow transport from Florida. Only when all of these conditions came together would it be possible to get a bloom off the coast of North Carolina.

The above account was the only reported case of a *K. brevis* bloom off the North Carolina coast. *K. brevis* blooms occur nearly every year off the Florida coast. Why, then, has a bloom not made it to North Carolina since?

## Procedure

1. Go to NOAA's Gulf of Mexico Harmful Algal Bloom Forecasting System Web site (current Web address: <http://www.csc.noaa.gov/crs/habf/>). This service provides alerts for HABs in the Gulf of Mexico to minimize possible human impacts.

What are the current conditions reported off the Florida coast?

2. Click on the "HAB bulletins" link. This page shows all of the bulletins that have been issued concerning possible HABs in the Gulf of Mexico since 2000.

Blooms of *K. brevis* can be transported by wind and also by currents. Using these bulletins, we can observe the movement of a *K. brevis* bloom. In November and December 2004, there was a well-defined bloom off of southwest Florida. Read through the HAB bulletins for 11/22/04 through 12/06/04. Each bulletin shows the movement of the bloom and the associated wind speed and direction. Does the bloom appear to move based on the prevailing winds? Explain and provide examples.

What was the overall distance the bloom was transported in the 14 days?

3. If there is a bloom in the Gulf of Mexico today, which direction would the winds need to blow in order for the bloom to be blown to shore? (Which direction would the winds have had to blow on December 6, 2004 in order for the bloom to be picked up by the Loop Current/Gulf Stream?)
4. Go to NOAA's National Data Buoy Center (current Web address: <http://www.ndbc.noaa.gov/>). This Web site provides current data of atmospheric and water conditions from buoys throughout the world. Choose the region or city along the west coast of Florida as a target. Then choose the buoy closest to the region or city you selected as a target. Are the winds blowing in the correct direction to move the bloom to shore toward your target area or city? Yes / No

Wind direction:

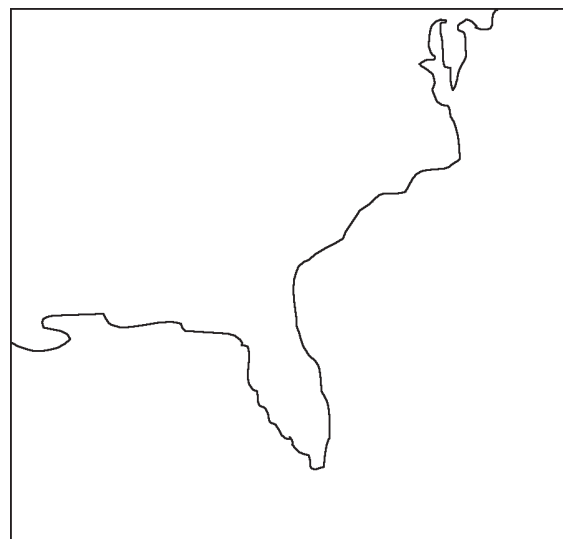
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Wind speed:

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5. If the bloom were able to enter the Loop Current/Gulf Stream, estimate how long it would take for the bloom to be transported from its current location in Florida to North Carolina? (Assume an average speed of 35–85 km/d for the Loop current and the Gulf Stream, and an average distance of approximately 100 km for each degree of latitude and longitude.)
6. Go to the Applied Physics Laboratory's (APL's) Ocean Remote Sensing Web page (current Web address: <http://fermi.jhuapl.edu/avhrr/>). This Web site provides current and historical satellite images of the Gulf of Mexico/Gulf Stream region. The images provided are representations of

sea surface temperature (SST). Warmer colors are shown in red and cooler colors are shown in purple. Because the Gulf Stream carries warm water northwards, it can be seen as a red "river" flowing within the ocean. View a current 7-day composite of the Gulf Stream and of the southern Gulf Stream (which shows the North Carolina region with higher resolution). Sketch the current path of the Gulf Stream.



7. Look in the archives for other images of the southern Gulf Stream.
  - a. Can you find instances where the Gulf Stream came closer to the North Carolina shore? Yes / No  
If yes, what dates? \_\_\_\_\_
  - b. Farther from the North Carolina shore? Yes / No  
If yes, what dates? \_\_\_\_\_

Based on these images, do you think it likely that the Gulf Stream could transport *K. brevis* to the coast based on today's location of the Gulf Stream? Explain your reasoning.

8. Go back to NOAA's National Data Buoy Center (current Web address: <http://www.ndbc.noaa.gov/>). Choose the region including North Carolina. What is the current

water temperature at station 41025, a station off the North Carolina Coast?

Current temperature:

Date:

*K. brevis* lives best at temperatures between 18 and 30°C. Based on temperature, could *K. brevis* be present in North Carolina waters today?

Yes / No

9. What other factors may also be important in influencing whether or not a bloom of *K. brevis* occurs?

## Questions

1. Why do you think that only one bloom of *K. brevis* has occurred off the coast of North Carolina?
2. How could scientists monitor the waters off North Carolina to warn the citizens if a *K. brevis* bloom could potentially occur?

Information for this activity was provided by Patricia Tester and the following articles:

P.A. Tester, and K.A. Steidinger, "*Gymnodinium breve* red tide blooms: Initiation, transport, and consequences of surface circulation," *Limnology and Oceanography*, vol. 42, pp. 1039–1051, 1997.

P.A. Tester, R.P. Stumpf, F.M. Vukovich, P.K. Fowler, and J.T. Turner, "An expatriate red tide bloom: Transport, distribution, and persistence," *Limnology and Oceanography*, vol. 36, pp. 1053–1061, 1991.

## Activity #2

Everyday in the newspaper there are articles relating to science and technology. Reading science articles is a very important skill to develop as it allows you to stay current on the ever-changing world of science.

### Procedure

Harmful algal blooms are observed every year off the coast of the U.S. Look through newspaper or magazine articles and on the Internet to research an HAB that occurred in the last year and answer the following questions.

## Questions

1. Where did the bloom occur?
2. What species was involved in the bloom?
3. Have similar blooms occurred in previous years?
4. What biological and physical conditions may have occurred to allow the bloom to develop (growth, losses, physics)?
5. Does the species produce a toxin? If so, what toxin? How does the toxin enter the body? What are the symptoms?
6. Were fish, marine mammals, birds or people effected by the bloom? If so, how?
7. What were the economic consequences of the bloom?
8. If you were a scientist, what aspect of the bloom would you study to help minimize the impacts of future blooms?